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SIMPLE PROBLEMS IN LAND MEASUREMENT

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Simple Problems In Land Measurement

By EARL G. WELCH

A farmer needs to know how to ascertain the area of a field and how to lay off a field to contain a given acreage, with reasonable accuracy. This circular describes simple, practical and sufficiently accurate methods for solving these problems. The need for instruction in land measurement is shown by a recent experience in the measurement of 270 fields, most of them irregular in shape, on 106 farms, in 6 counties. Fifty-nine farmers, whose tobacco acreage averaged 4.40 acres per farm, overestimated the acreage by an average of nearly one acre per farm. Thirty-four farmers, whose acreage averaged 7.50 acres per farm, underestimated the acreage by an average of nearly an acre and a quarter per farm. Only thirteen of the 106 farmers estimated their acreages correctly to within 0.1 acre. Pacing or stepping distances does not give accurate measurements. Men seldom agree on distances determined by this method.

Problems in land measurement are easier if the fields are of simple, regular shapes, with straight boundary lines. Curved, irregular boundary lines make computations more difficult and increase the chances for error. This should be kept in mind when a field is being laid out.

TO MEASURE A FIELD

Equipment. A cloth or steel tape marked in feet may be used for making measurements. If no tape is available, it is suggested that a surveyor's chain be made according to the instructions in this circular. Use of the chain as the unit of measurement simplifies calculation.

Measurement in Chains. The most convenient unit of measurement is the surveyor's chain which is 66 feet long. A square chain is equal to 4356 square feet (66 ft. x 66 ft.). Since an acre contains 43560 square feet, 10 square chains are equal to one acre.

A standard chain is divided into 100 links each 7.92 inches long. A distance measured in chains should be expressed decimally; for example, 6 full lengths of the chain and 18 links should be recorded as 6.18 chains. If a rectangular field is 6.18 chains long and 5.10 chains wide the area may be obtained by multiplying 6.18 chains by 5.10 chains. The product, 31.518 square chains, is reduced to acres by dividing by 10, or moving the decimal point one place to the left, so that 31.518 square chains equals 3.15 acres.

Measurement in Feet. In many instances distances will be measured in feet. Tables for converting acres to square feet and square feet to acres are provided in this circular (Tables 1 and 2). The use of these tables avoids tedious multiplication and division.

Boundaries. In measuring an area planted to a row crop or in laying off an area to be planted, the measurements should include a distance beyond the rows on all sides equal to half the distance between rows. In fields seeded to wheat, a distance of one foot outside the drill rows should be included in the seeded area.

Number of Plants per Acre. Where tobacco is checked, as it is in western Kentucky, a common practice is to estimate acreage by the number of plants set. This method is satisfactory for calculating acreage in connection with tobacco production, provided the correct number of plants per acre is used in the calculation. Table 3 shows the number of plants on an acre of ground for spacings ranging by inches from three to four feet. The total number of plants to be set may be determined by multiplying the number of plants per acre which corresponds to the adopted spacing by the number of acres to be set.

TO CALCULATE THE AREA OF A FIELD

Acre equivalents.

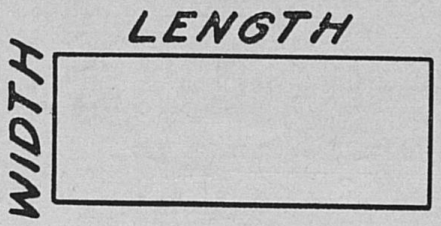
1 acre = 43560 square feet, or 10 square chains.

1 acre = 4840 square yards, or 160 square rods.

Square feet are reduced to acres by dividing by 43560 or by means of Table 2.

Square chains are reduced to acres by dividing by 10, or moving the decimal point one place to the left.

Rectangles. Rectangular and square fields are those in which all interior angles are right angles. The area of a rectangular field is equal to the product of its length by its width.

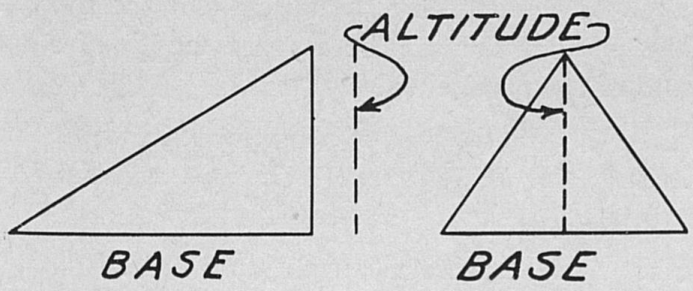


Problem. What is the area of a rectangular field 660 ft. (10 chains) long and 330 feet (5 chains) wide?

Formula. Area = length × width.

Solution. (Measurements in feet.)
660 ft. × 330 ft. = 217800 square feet.
217800 sq. ft. ÷ 43560 = 5 acres (Table No. 2).

Solution. (Measurements in chains.)
10 chains × 5 chains = 50 square chains.
50 square chains ÷ 10 = 5.0 acres.



Triangles. Triangular fields are those with three sides. If the triangle has one square corner it is called a right triangle. Any side of a triangle may be called the base. The altitude is the shortest distance between the base and the opposite corner. The area of a triangle is equal to half the product of the base by the altitude.

Problem. What is the area of a triangular field which has a base of 792 feet (12 chains) and an altitude of 800 feet (12.12 chains) ?

Formula. $\text{Area} = \frac{\text{base} \times \text{altitude}}{2}$

Solution. (Measurement in feet)

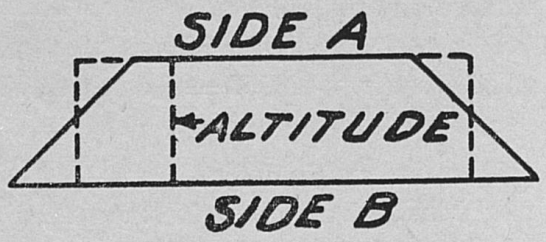
$$\text{Area} = \frac{792 \text{ ft.} \times 800 \text{ ft.}}{2} = 316800 \text{ square feet.}$$

316800 square feet = 7.3 acres (see conversion table No. 2).

Solution. (Measurement in chains)

$$\text{Area} = \frac{12 \text{ chains} \times 12.12 \text{ chains}}{2} = 72.7 \text{ square chains.}$$

72.7 sq. chains = 7.27 acres.



Trapezoids. A trapezoid is a four-sided figure that has only two sides parallel. The altitude of a trapezoid is the shortest distance between the parallel sides. The average length of a trapezoid is half the sum of the parallel sides.

Problem. What is the area of a trapezoid in which side A is 462 feet (7 chains), side B, 594 feet (9 chains), and the altitude, 198 feet (3 chains)?

Formula. Area = average length × altitude.

Solution. (Measurement in feet)

$$\text{Area} = \frac{462 \text{ ft} + 594 \text{ ft.}}{2} \times 198 \text{ ft.} = 104544 \text{ square feet.}$$

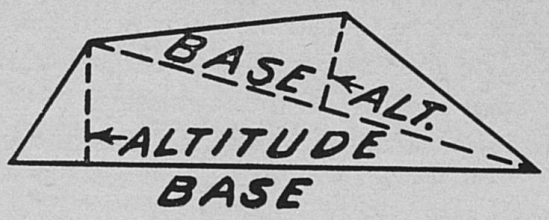
104544 square feet = 2.4 acres (see conversion table No. 2).

Solution. (Measurement in chains)

$$\text{Area} = \frac{7 \text{ chains} + 9 \text{ chains}}{2} \times 3 \text{ chains} = 24 \text{ square chains}$$

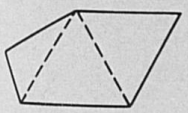
$$24 \text{ square chains} = 2.4 \text{ acres.}$$

Trapeziums and Fields of More than Four Sides. A trapezium is a four-sided figure that has no two sides parallel. The area of such a figure is obtained by dividing it into two triangles and calculating

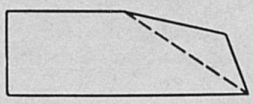


the area of each triangle separately as explained under triangles. The base and altitude of each triangle should be measured.

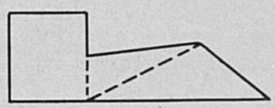
The illustrations show how various shaped fields may be divided into triangles, rectangles and trapezoids. By careful preliminary



3 triangles

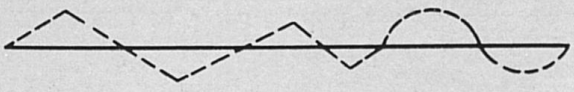


1 trapezoid, 1 triangle



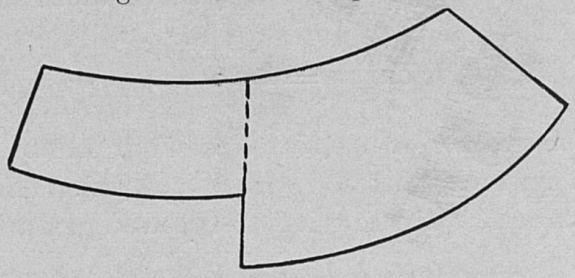
1 rectangle, 2 triangles

examination the best method of subdividing an irregular field can be determined so that unnecessary measurements are avoided. A sketch of the field should be made before measurements are taken. The sketch should be kept for reference.

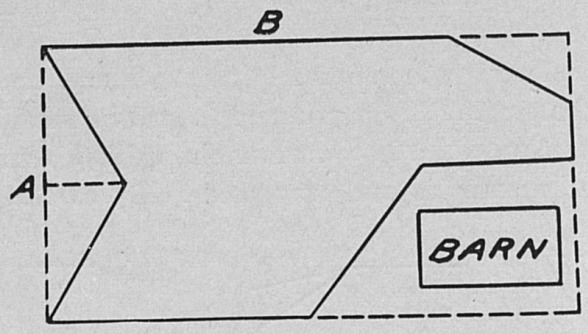


Areas with Irregular or Curved Sides. An irregular side of an area may be measured as a straight line, as indicated by the solid line in the diagram, provided the amounts of land on opposite sides of the straight line are equal or approximately equal.

Where sides of a field are curved, as they frequently are where contour planting is done, the approximate area may be obtained by multiplying the average width of a strip by its average length. The



average width and length should be determined from two or more measurements. The figure above illustrates an area with curved sides which has been subdivided into two strips of different lengths and widths. The sum of the two areas is the total area.



The irregular shaped field shown above may be measured as a rectangle. By subtracting the areas between the dotted lines and the solid lines, from the area of the rectangle, the planted area may be determined in less time and more accurately than by any other method. The field sketch should include the necessary dimensions for determining the areas to be subtracted in addition to the dimensions of the rectangle.

TO LAY OUT A FIELD OF A GIVEN AREA

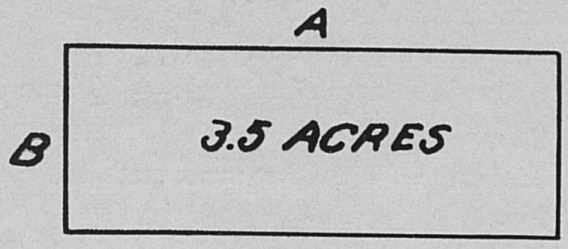
1 acre = 43560 square feet or 10 square chains.

1 standard chain = 66 feet, or 100 standard links each 7.92 inches long.

1 homemade chain = 66 feet, or 19 long links each 5 standard links long, and 5 standard links.

Rectangles.

Problem. A rectangular field is to contain 3.5 acres and side B is 297 feet, or 4.5 chains, long. What should be the length of side A?

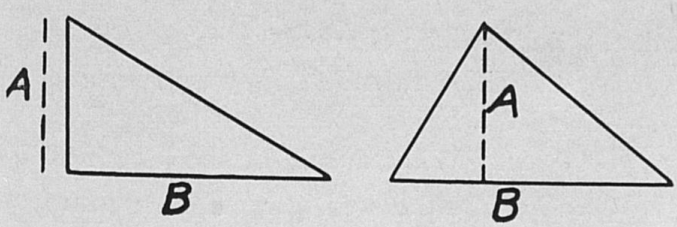


Method. Convert acres to square feet or square chains, according to the unit of measurement to be used, and divide this figure by the length of the known side. The answer is the length of the other side.

Formula. Area of rectangle = width × length; therefore unknown side = area divided by known side.

Solution. (Measurements in feet.)
3.5 acres = 152460 square feet (see conversion table number 1)
152460 square feet ÷ 297 ft. (side B) = 513.3 ft. (side A).

Solution. (Measurements in chains.)
3.5 acres = 35 square chains (1 acre = 10 square chains)
35 square chains ÷ 4.5 chains = 7.77 chains (side A).



A = altitude. B = base.

Triangles. Because the area of a triangle is equal to half the product of the base by the altitude, which is the same as half the base multiplied by the altitude, it follows that the area divided by half the base gives the altitude.

Problem. A triangular field is to contain 3.5 acres. The base

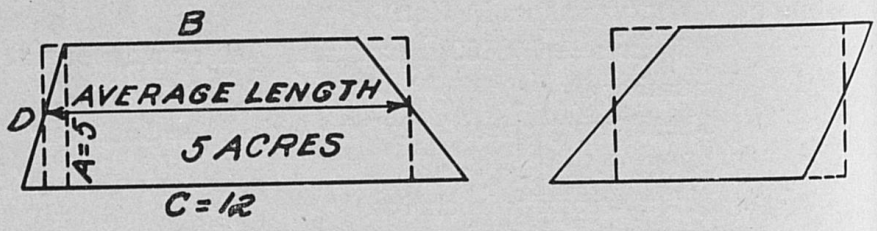
B is 11 chains, or 726 feet. What should be the length of A, the altitude?

Method. Convert the area to square feet or square chains, according to the unit of measurement to be used, and divide this figure by ½ the length of the base. The answer is the altitude.

Formula. Altitude = area of triangle ÷ ½ base

Solution. (Measurement in feet.)
3.5 acres = 152460 square feet (see conversion table No. 1)
152460 square feet ÷ 363 feet (½ of 726 feet) = 420 feet (the altitude)

Solution. (Measurements in chains)
3.5 acres = 35 square chains.
35 square chains ÷ 5.5 chains (½ of 11 chains) = 6.36 chains (the altitude).



Trapezoids. Because the area of a trapezoid is equal to the product of the average length by the altitude, it follows that the area divided by the altitude gives the average length.

Problem. A field in the shape of a trapezoid is to contain 5 acres. The altitude A between parallel sides B and C is 5.00 chains, or 330 feet. Side C is 12 chains, or 792 feet. What should be the length of side B?

Method.
1. Convert the area in acres to square feet or square chains, according to the unit of measurement to be used.
2. Divide the area in square feet or square chains by the altitude in feet or chains. The result will be the average length of the field or the sum of the opposite parallel sides B and C divided by 2.
3. Multiply the average length of the field by 2 and

subtract the known side C. The result will be the length of the side opposite C or side B.

Formulas. Average length $= \frac{\text{sum of parallel sides}}{2}$

Average length = area ÷ altitude.

An unknown parallel side = 2 × average length minus known parallel side.

Solution (Measurements in feet.)

5 acres = 217800 square feet (see conversion table No. 1).

217800 square feet ÷ 330 feet (altitude, A) = 660 ft. (the average length of the field).

660 ft. × 2 = 1320 ft.

1320 ft. − 792 ft. (side C) = 528 ft. (side B)

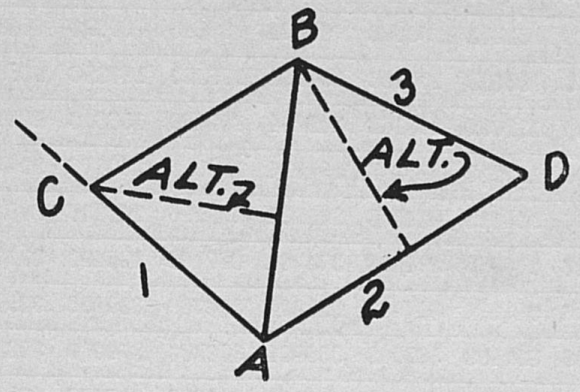
Solution. (Measurements in chains)

5 acres = 50 square chains

50 square chains ÷ 5 chains = 10 chains (the average length of the field)

10 chains × 2 = 20 chains

20 chains − 12 chains (side C) = 8 chains (side B).



Trapeziums. The area of a trapezium is equal to the sum of the areas of two triangles.

Problem. To lay off a given acreage where three boundary lines, two of which are fixed in direction and length and the third in direction only, as 1 and 2 and 3 above, cause the fixed area to resemble a trapezium.

Method. 1. Using two of the fixed sides 2 and 3 make a triangle such as A D B and determine its area.

2. Subtract area of triangle A D B from the total area to be planted. The remainder is the area to be added to triangle A D B, to complete the acreage.
3. Calculate the altitude of a triangle A B C to contain the additional area, by method described under the heading "Triangles," page 9, using the line A B as the base. The two triangles together contain the required area.

CONVERSION TABLE NO. 1. ACRES TO SQUARE FEET

The number of square feet in a given area can be determined from this table as follows: Read down the column on the left, headed A (acres), to the desired number, then to the right to the block directly under the proper decimal figure.

Example. To find the number of square feet in 9.6 acres, follow down the acres column on the left to 9, then to the right to the block under .6. The number found, 418176, is the number of square feet in 9.6 acres.

A.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0		4356	8712	13068	17424	21780	26136	30492	34848	39204
1	43560	47916	52272	56628	60984	65340	69696	74052	78408	82764
2	87120	91476	95832	100188	104544	108900	113256	117612	121968	126324
3	130680	135036	139392	143748	148104	152460	156816	161172	165528	169884
4	174240	178596	182952	187308	191664	196020	200376	204732	209088	213444
5	217800	222156	226512	230868	235224	239580	243936	248292	252648	257004
6	261360	265716	270072	274428	278784	283140	287496	291852	296208	300564
7	304920	309276	313632	317988	322344	326700	331056	335412	339768	344124
8	348480	352836	357192	361548	365904	370260	374616	378972	383328	387684
9	392040	396396	400752	405108	409464	413820	418176	422532	426888	431244
10	435600	439956	444312	448668	453024	457380	461736	466092	470448	474804
11	479160	483516	487872	492228	496584	500940	505296	509652	514008	518364
12	522720	527076	531432	535788	540144	544500	548856	553212	557568	561924
13	566280	570636	574992	579348	583704	588060	592416	596772	601128	605484
14	609840	614196	618552	622908	627264	631620	635976	640332	644688	649044
15	653400	657756	662112	666468	670824	675180	679536	683892	688248	692604

CONVERSION TABLE NO. 2. SQUARE FEET TO ACRES

Locate the block within which the number falls. Travel to left margin where acreage is shown in units. Travel upward to where additional fractional parts of acre is shown. By combining these the total acreage is obtained to the nearest 0.1 acre.

A.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0			6535	10891	15247	19603	23959	28315	32671	37027
		6534	10890	15246	19602	23958	28314	32670	37026	41382
1	41383	45739	50095	54451	58807	63163	67519	71875	76231	80587
	45738	50094	54450	58806	63162	67518	71874	76230	80586	84942
2	84943	89299	93655	98011	102367	106723	111079	115435	119791	124147
	89298	93654	98010	102366	106722	111078	115434	119790	124146	128502
3	128503	132859	137215	141571	145927	150283	154639	158995	163351	167707
	132858	137214	141570	145926	150282	154638	158994	163350	167706	172062
4	172063	176419	180775	185131	189487	193843	198199	202555	206911	211267
	176418	180774	185130	189486	193842	198198	202554	206910	211266	215622
5	215623	219979	224334	228691	233047	237403	241759	246115	250471	254827
	219978	224334	228690	233046	237402	241758	246114	250470	254826	259182
6	259183	263539	267895	272251	276607	280963	285319	289675	294031	298387
	263538	267894	272250	276606	280962	285318	289674	294030	298386	302742
7	302743	307099	311455	315811	320167	324523	328879	333235	337591	341947
	307098	311454	315810	320166	324522	328878	333234	337590	341946	346302
8	346303	350659	355015	359371	363727	368083	372439	376795	381151	385507
	350658	355014	359370	363726	368082	372438	376794	381150	385506	389862
9	389863	394219	398575	402931	407287	411643	415999	420355	424711	429067
	394218	398574	402930	407286	411642	415998	420354	424710	429066	433422
10	433423	437779	442133	446491	450847	455203	459559	463915	468271	472627
	437778	442134	446490	450846	455202	459558	463914	468270	472626	476982
11	476983	481339	485695	490051	494407	498763	503119	507475	511831	516187
	481338	485694	490050	494406	498762	503118	507474	511830	516186	520542
12	520543	524899	529255	533611	537967	542323	546679	551035	555391	559747
	524898	529254	533610	537966	542322	546678	551034	555390	559746	564102

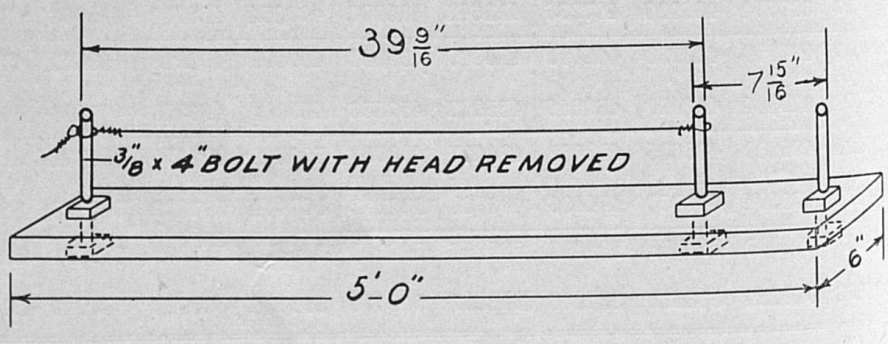
TABLE NO. 3. NUMBER OF PLANTS PER ACRE*

Spacing	Sq. Ft. Per Plant	No. Plants Per Acre
3′ x 3′	9.	4840
3′ –1″ x 3′ –1″	9.48	4590
3′ –2″ x 3′ –2″	10.03	4343
3′ –3″ x 3′ –3″	10.56	4125
3′ –4″ x 3′ -4″	11.08	3930
3′ –5″ x 3′ –5″	11.67	3733
3′ –6″ x 3′ –6″	12.25	3555
3′ –7″ x 3′ -7″	12.81	3400
3′ –8″ x 3′ –8″	13.40	3250
3′ –9″ x 3′ –9″	14.06	3100
3′–10″ x 3′–10″	14.67	2970
3′–11″ x 3′–11″	15.33	2842
4′ -0″ x 4′ –0″	16.00	2722

*43560 square feet equals 1 acre.

A HOMEMADE CHAIN FOR MEASURING LAND

A homemade chain can be made easily out of baling wire or No. 12 wire, on the device shown below. Make each long link 39 5/8″ long, which is equivalent in length to five links of the standard surveyor's chain. Twenty links 39 5/8″ long make a chain 66 feet in length. At one end of the chain 5 standard links 7.92 inches in length may be made in place of one of the long links, to be used in measuring short distances.



The length of the finished link should be 3.3 feet, but the bolts should be placed $39^{9}/_{16}$″ apart, outside measurement, to allow for the tendency of the link to lengthen while making the eye joints.

Steps in Making a Homemade Chain.

1. Cut 19 wires 43″ long for long links.
2. Cut five wires 11½″ long for short links.
3. With a pair of pliers bend and twist the wire around the bolts to form an eye in each end, being careful to keep wire taut between bolts.
4. Slip the end of the wire of next link thru the eye of the preceding link before forming the eye on it.
5. After the 66 ft. chain is completed, check the length of each link and the length of the chain with a standard steel tape. The length of a link can be made to conform to the standard link by bending the eyes to make them shorter or longer.
6. A harness ring or a piece of rawhide should be fastened to each end for greater ease of handling.
7. When the chain is not in use, the links should be folded into a bundle and tied with a piece of string or rawhide.

TO MEASURE WITH A HOMEMADE CHAIN

In making measurements with the homemade chain, fractional parts of a chain are expressed decimally. Each long link is counted as 5 links, or 0.05 chain. The short links at the end of the chain are 1 link or 0.01 chain each. For example, if a given distance is measured as 9 full chains plus 8 long links, plus 6 short links, the distance should be recorded as 9.46 chains.